EXHIBIT A

UNITED STATES DISTRICT COURT

WESTERN DISTRICT OF WASHINGTON

CITY OF SEATTLE, a municipal corporation located in the County of King, State of Washington, Plaintiffs, v. MONSANTO COMPANY, SOLUTIA INC., and PHARMACIA CORPORATION, and DOES 1 through 100, Defendants.	CASE NO. 2:16-cv-00107-RAJ

EXPERT REBUTTAL REPORT OF CHARLES D. COWAN, Ph.D.

February 14, 2022

Contents

A. Summary of Engagement

1. I was retained by Keller Rohrback L.L.P. and Stoll Berne counsel for Plaintiff, the City of Seattle (the "City") to review the statistical methods used in several reports submitted by the Defendants. In addition, I was asked to review specific statistical methods used to estimate the number of persons fishing on the Lower Duwamish Waterway (LDW).

2. One of the reports I reviewed is the report submitted by Dr. David Sunding[1] on behalf of the Defendants. Dr. Sunding's report purportedly estimates the number of persons fishing in the Lower Duwamish Waterway. I reviewed reports by Dr. Richard Pleus[2] and Dr. David Eaton[3], submitted on behalf of the Defendants, to examine the extent to which their reliance on Dr. Sunding might be impacted by any conclusions I draw about Dr. Sunding's report. These experts in turn rely on other reports and papers. I also examined in detail the statistical methodologies that Dr. Pleus implemented to determine whether his methodologies adhered to sound and accepted statistical principles. Any relevant materials cited in these expert reports are referenced in my reviews of the work of each of these experts and presented in an appendix that presents materials on which I relied.

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[1] Expert Report of David L. Sunding, Ph.D., submitted November 22, 2021

[2] Expert Report of Dr. Richard C. Pleus: Human Health Risk Assessment for PCB Contamination in the Lower Duwamish Waterway, submitted November 22, 2021

[3] Expert Report of David L. Eaton, Ph.D., DABT, FATS, submitted November 22, 2021

3. This report details my work, findings, and opinions. I reserve my right to amend or supplement this report should additional documents or information become available to me.

B. Conclusions

4. Dr. Sunding uses the Chao Estimator[4] to estimate the number of persons who recreationally fish in the Lower Duwamish Waterway and who consume fish caught. Dr. Sunding made several fatal errors in applying the estimator. The methods and results from Dr. Sunding are severely flawed and are unreliable.

5. Dr. Sunding uses data collected for purposes other than population size estimation that he obtains from reports he cites. The authors of the key report that Dr. Sunding uses state that their survey was not designed to be used to calculate population estimates. This data is not suitable or appropriate to use to estimate population sizes.

6. Dr. Eaton relies on the results from Dr. Sunding in his report, but as Dr. Sunding's estimates are severely flawed and unreliable, the results presented by Dr. Eaton are also severely flawed and unreliable.

7. Dr. Pleus relies on the results from Dr. Sunding in his report, but as Dr. Sunding's estimates are severely flawed and unreliable, the results presented by Dr. Pleus are also severely flawed and unreliable.

[4] Chao, Anne. "Nonparametric Estimation of the Number of Classes in a Population", Scandinavian Journal of Statistics, 11: 265-270, 1984.

8. In addition, Dr. Pleus violates numerous statistical principles and implements statistical methodologies that are wrong and misleading, regardless of the inputs he uses in his analysis. Again, the methods employed by Dr. Pleus are severely flawed and unreliable.

9. There are methods for the estimation of population size that are recognized by statisticians as reliable. Many of these methods are referenced in the Chao Paper. Dr. Sunding could have used any of these methods but instead chose an inappropriate method and data that yields unreliable results.

10. There are well-defined principles for computation of summary statistics that are recognized by statisticians. Dr. Pleus could have used any of these methods but instead chose inappropriate methods that yield unreliable results.

C. Professional Qualifications and Compensation

11. I have over fifty years of experience in statistical research and design. I have a doctorate in Mathematical Statistics from the George Washington University. My professional experience and academic tenure are included in my curriculum vitae, a true and correct copy of which is attached as Exhibit 1.

12. My firm, Analytic Focus LLC, is being compensated for my work on this engagement at the rate of $775 per hour for my time. The payment of fees to Analytic Focus is not contingent on the opinions I express in connection with this engagement.

13. Cases where I have given testimony in the past four years are listed in Exhibit 2. The materials I considered in forming my opinions are listed in Exhibit 3.

D. Estimation of Population Size

D.1 Capture-Recapture Methods and the Estimation of Population Size

14. Dr. Sunding relies on a paper published by Dr. Anne Chao in 1984[5] regarding the estimation of the number of classes in a population. In the 1984 article, Dr. Chao points out "The problem of estimating the number of classes is equivalent to that of estimating the total number of individuals in capture-recapture studies." Capture-recapture methods have been in existence for a very long time and are one of several techniques used to estimate the size of a population.

15. Capture-recapture methods have been developed in different fields for different purposes. The first reported use was in 1783 by the French mathematician LaPlace to estimate the population size of Paris France. In 1898, capture-recapture was employed by C.G. Johannes Peterson to estimate the number of flatfish in a pond, again by Frederick Lincoln in 1930 to estimate waterfowl abundance in the U.S. based on bird-banding, by Hans Geiger to measure radiation from different radioactive sources (before the invention of the Geiger counter), and by Chandrasekar and Deming in 1949 to estimate the extent of registration of births and deaths in India. All of these estimators,

[5] Ibid.

though developed independently and in very different fields of study, are identical and the estimator that each derived is now known as the Lincoln-Peterson estimator.

16. To estimate the completeness of the Decennial Census of Population and Housing, the Census Bureau adopted the use of capture-recapture methods. I led the program to estimate the Census Undercount for the 1980 Census. We tested methods to estimate the undercount and implemented a massive effort in 1980 to estimate the extent of the undercount and overcount in each of the 50 states, the District of Columbia, Puerto Rico, and multiple Standard Metropolitan Statistical Areas (SMSAs).

17. This study was known as the Post Enumeration Program and incorporated a sample of thousands of geographic blocks. These blocks were re-enumerated and then matched to the census taken in the same blocks. The results were used with a capture-recapture estimator and then extrapolated from the sample of blocks to the full population in the United States. Results were delivered to the President and Congress after the Census counts were delivered.

18. While the effort at estimating the undercount proceeded, more than 50 states and cities filed lawsuits attempting to force the Census Bureau to adjust the 1980 Decennial Census counts based on the results of this study. A goal in the lawsuits was to force higher counts in some states so that a seat in the House of Representatives would shift from one state to another,

19. A second goal was to affect redistricting within states to force a restructuring of seats for the House of Representatives as well as restructuring of state legislatures. A third goal was to affect the allocation of Federal revenue sharing monies to states and to local areas based on adjusted Census counts. The lawsuits proceeded over a number of years, and I testified in lawsuits related to the claims of New York State and New York City.

20. I developed several modifications or enhancements to the capture-recapture estimator during this time, many of which are still in use at the Census Bureau today. One enhancement was to use information captured about subpopulations within the counts to improve the quality of the estimates, particularly with respect to racial distributions and the differential undercount in the Census.

21. A second modification was to develop a multi-step estimator so that estimates of undercount in housing were made simultaneously with estimates of undercount in the population, accounting now for whole families or households who were missed if a residential unit was missed in the Census.

22. Following my work on the U.S. Decennial Census, I worked on the Census evaluation in other countries, particularly in Africa, Latin America, and the Far East. In Egypt, for example, I worked with the Egyptian government on implementation of capture-recapture methods in estimating the population size using their Census in cities. In Somalia, I designed a watering point Census count and evaluation for nomadic

tribesmen who lived by herding livestock to watering points in the country. In China, I worked with local government officials on evaluation of their agricultural census.

23. As a Visiting Research Professor at the University of Illinois, I won a grant from the Department of Justice to develop methods of counting the number of missing children in the United States. As a consultant to Johns Hopkins University, I won a grant from the National Institute of Mental Health to count the number of homeless in cities. In my own firm, I won a grant from the National Institutes of Health to estimate the number of health care workers in the United States to support NIH's STEM initiative.

24. I've published numerous articles on the use of capture-recapture methods, including articles in Science[6], the premier scientific journal in the United States, in a book, Homelessness, Health, and Human Needs[7], regarding social network needs of the homeless published by the National Academy of Sciences, as well as a book I co-authored which was published by the Bureau of the Census.

25. Some of my work has focused on reviews of statistical models employed by other Federal agencies, by financial institutions, or in Congressional inquiries. My review

[6] Sudman, Seymour, Sirken, Monroe G., and Cowan, Charles D., "Sampling Rare and Elusive Populations", Science, Vol. 240, pp. 991 996, May 20, 1988.
[7] Cowan, Charles D., Breakey, William R., and Fischer, Pamela J. "The Methodology of Counting the Homeless, A Review" in Homelessness, Health, and Human Needs. Institute of Medicine, National Academy Press, National Academy of Sciences, Washington, D.C., 1988.

of Dr. Sunding's work and the work of Drs. Eaton and Pleus is similar in nature to the evaluative work I have done over the last forty years.

D.2 Dr. Sunding's Inappropriate Use of Capture-Recapture Methods

26. Methods used to estimate population size require two things: a statistical model that relies on probabilities that a population member is observed, and appropriate data to estimate parameters in that statistical model. Many problems in the sciences have the same requirements: use of a statistical model to describe some process, and the appropriate data from that process to allow one to estimate the parameters in that model. In most scientific problems, there is a well-defined population where the population size is known and characterized by the parameter N, a fixed number. Statistical models where N is unknown are less common, but there are recognized ways to reliably estimate the size of the population.

27. A single count of people or items in a population is never sufficient for the estimation of a population size, since there is always the possibility of a mistake. The single count does not contain enough information to enable estimation of a population size, but with two samples of the population, one can estimate the population size "N" using a capture-recapture model. Table 1 demonstrates this method. This example will be important to understanding the Chao estimator in the next section.

28. Suppose one wants to know the number of fish in a lake. A net is cast in the lake to haul up fish. A count is made of fish caught, "F." The fish captured in the net

are tagged and released back into the lake. A second net is cast, and the fish caught the second time are counted. The count of the second catch is "S" and the number of fish previously tagged also are enumerated. The count of fish caught both times is "B."

29. A simple assumption is made, that the chance of catching a fish in the second attempt is the same for all fish, regardless of whether the fish was caught previously. An estimate of the total number of fish, N, is based on relationships defined in this tabulation.

Table 1: Tabulation for Capture-Recapture Estimation of Population Size

		First Attempt		
		Observed	Not Observed	Total
Second Attempt	Observed	B		S
	Not Observed			
	Total	F		N

Where N is what we want to know, N = the population size
F is the count of items from the First Attempt to count the population
S is the count of items from the Second Attempt to count the population, and
B is the count of items observed in Both count attempts

30. If fish have the same chance of being caught in the second catch, regardless of whether they were caught in the first catch, then the proportion of fish caught overall (S/N) is the same for all fish as for only those who were caught in the first catch (B/F). This means that these rates are equal.

$$\frac{B}{F} = \frac{S}{N}$$

31. Some simple algebra allows one to rearrange to solve for the value N:

$$F * \frac{B}{F} = \mathrm{F} * \frac{S}{N}$$

$$N * B = \mathrm{N} * \frac{F * S}{N}$$

$$\frac{1}{B} * B * N = \frac{1}{B} * F * S$$

$$N = \frac{F*S}{B}$$

32. As an example, suppose the number of fish caught in the first sample ("F") is 80 and the number of fish are caught in the second sample ("S") is 130. After a review of the second catch, 20 fish are found to be tagged and so the 20 were also caught in the first catch ("B"). Then N = 80*130/20 = 520 fish estimated to be in the lake.

33. This model assumes all fish have the same probability of capture within the first sample of F/N (80/520 = .154 in the example). This model also assumes all fish have the same probability of capture of S/N (130/520 = .250) when the second net is thrown. Thus all fish have the probability of observed of .154 in the first catch, .250 in the second catch, and the two probabilities can differ from catch to catch. The only assumptions being made are that all members of the population have the same probability of being caught in any catch effort (catch one or catch two), and that being caught the first time does not make a member of the population more or less likely to be caught a second time[8].

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[8] Op. Cit. Sudman, Sirken, and Cowan.

34. To summarize, models for estimation of population size have several assumptions and requirements. As I noted in my paper on counting the homeless[9] the most important assumptions in the capture-recapture method are:

i. Clear definitions: Homeless people can be accurately identified.
ii. Homogeneous observation probabilities: Each person has the same chance of being observed in a specific period.
iii. Stability: The size and nature of the population does not change during the observation period.
iv. Stationarity: The population does not move in or out of the study area during the observation period.
v. Independent captures: For the periods, the order interaction term (however defined) is zero; that is, even though a homeless person was observed at one period, it does not affect the probability that the person will be observed on subsequent occasions.
vi. Data correctness: The information collected is accurate.
vii. Complete response: Individuals or informants provide information that is complete enough to permit matching.
viii. Matching correctness: Data records for the same individuals can be linked between observation periods.
ix. Single observations: Individuals are observed only once at each data collection.
x. Known externalities: Factors that affect the data collection are known and can be accounted for, such as weather conditions and receipt of welfare checks.

[9] Op. Cit. Cowan, Breakey, and Fischer.

35. Material violations of these assumptions invalidate the model, causing the results to be biased and unreliable. More complex models allow for all exigencies, but more complex models require more data and may be impractical.

D.3 Relating Dr. Chao's Estimator to the Capture-Recapture Model

36. Table 1 also describes a way to portray the Chao estimator, used by Dr. Sunding, although Dr. Chao makes one other assumption in her paper. Dr. Chao relaxes the assumption of equal probabilities of capture for members of a population in any one catch. In Dr. Chao's model, every member of a population can have a different (but non-zero) probability of being caught, but at each catch that probability is the same. Put another way, if a member of a population has an 11% chance of being caught in the first sample, that member carries along an 11% chance of being caught in each later catch effort. The number varies from population member to population member but remains that same over catches for each population member.

37. Dr. Sunding uses the Chao Estimator to estimate the expected number of people who fish in the Lower Duwamish Waterway. "Specifically, I estimate the size of the total LDW angling population using Chao's estimator, a method that is commonly used to estimate population sizes in the ecology literature."[10]

[10] Expert Report of David Sunding, para. 39.

38. Revisiting Table 1, offered previously in this report, I can put the same table in terms using Dr. Chao's notation. This is shown in Table 2.

Table 2: Tabulation for Capture-Tag-Recapture Estimation of Population Size

		First Attempt		
		Observed	Not Observed	Total
Second Attempt	Observed	f_2	f_1 (2)	S
	Not Observed	f_1 (1)	f_0	N - S
	Total	F	N - F	N

Where N is what we want to know, N = the population size,

f_2 is the count of items observed twice
$f_1 = f_1\ (1) + f_1\ (2)$ is the count of items observed only once
f_0 is the unobserved number of items, which Dr. Chao estimates
f_1 (1) is the count of items from the First Attempt observed only once
f_1 (2) is the count of items from the Second Attempt observed only once

and Chao's estimator is: $N = f_1 + f_2 + \frac{f_1 f_1}{2 * f_2}$

D.4 Three Fatal Flaws in Dr. Sunding's Use of the Chao Estimator

39. There are numerous problems with Dr. Sunding's application of the Chao estimator, but the key flaw in Dr. Sunding's work is that the Chao estimator, like all capture-recapture estimators, relies on each unit in the population having a non-zero probability of being observed. If you can't be seen, you can't be counted.

D.4.1 Fatal Flaw 1: Population Members Move In and Out of The Observation Area

40. In the fish in the lake example, every fish is in the lake at any time I visit the lake. The fish do not leave the lake. When I go back the second time to net fish in the lake, I expect that the fish swim around but that the fish that were in the lake the first time are in the lake a second time, and my net is a random "grab" throughout the lake.

41. A similar popular example is estimating the number of jellybeans in a jar. The participant closest to the actual number wins a prize. You can sample the jellybeans, mark the jellybeans in some manner, return the beans to the jar, shake vigorously, and sample a second time. The jellybeans in the jar for the second sample are the same beans sampled the first time. Since jellybeans are returned to the jar, at any time one samples, all the jellybeans are present and available to be sampled.

42. In the examples above, the only random factor is in the selection of members of the population, where each member of the population has a chance of inclusion in each sample. There is no randomness as to whether a member of the population will be available to be sampled. The estimators in Tables 1 and 2 are both generally accepted in statistics and reliable.

43. But there is no stability to the population for the data that Dr. Sunding is using. "Fishers" are not always fishing – they come, and they go.

44. In an article regarding public health, Watts, Zwi, and Foster[11], the authors find a similar problem. They are attempting to count the number of sex workers who operate in a city on the border between two countries. They observe that the people they want to count are moving in and out of the population. Sometimes they are sex workers, and sometimes they aren't, depending on their economic circumstances. Similarly, they move in and out of area being sampled, since they sometimes work in the city being studied, and sometimes work in other areas outside the city. They note that this problem can lead to severe underestimates of the size of the population under study.

45. Dr. Sunding makes no mention of differential availability to be counted. He does consider differential frequency of anglers going fishing, but he makes another error in adjusting for these frequencies, as discussed in the following section.

D.4.2 Fatal Flaw 2: Adjusting for Differential Frequency of Fishing by Anglers

46. In a section titled "Correcting for Oversampling of Frequent Anglers ", Dr. Sunding states:

the probability of interviewing an angler that fishes every day for 8 hours is much higher than that of an angler who only fishes once per year. If consumption patterns systematically

[11] Watts, Charlotte H., Zwi, Anthony B, and Foster, Geoff, "How to do (or not to do) … Using capture-recapture in promoting public health", in Health Policy and Planning, 10(2): 1988-203, Oxford University Press, 1995

differ across these respondents and the differing chances of being interviewed are not accounted for, the estimated consumption rates will be biased.[12]

47. Dr. Sunding recognizes that the anglers being interviewed fish at different rates, and thus have different observation probabilities. He makes an adjustment based on an EPA recommendation regarding a completely different study design by the EPA.

48. What Dr. Sunding misses is that Dr. Chao's purpose in deriving her formula is to account for unequal probabilities of capture in the capture-recapture model. In her 1984 paper, Dr. Chao starts by making random selections from a population but with different probabilities that a sampled member belongs to a particular class. In this paper she focuses on estimating the number of classes into which a population can be divided.

49. In Dr. Chao's 1987 paper, which more fully describes the same estimator as useful for estimating population size, she states that she is proposing

an estimator and its associated confidence interval for the population size under the heterogeneity model. … Assume the population is closed with size N and there are t trapping occasions, let the individuals be indexed by 1, … , N and p_{ij} *be the capture probability of the ith individual on the jth trapping occasion. We further assume* $p_{ij} = p_i$ *for* $j = 1, \dots, t$.[13]

50. What Dr. Chao is saying is that she starts by assuming that there are different capture probabilities for each person in the population (the subscript "i" on the probability "p" varies), and she develops an estimator that accounts for this variability in

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[12] Sunding report, paragraph 31

[13] Chao, Anne. "Estimating the Population Size for Capture-Recapture Data with Unequal Catchability", Biometrics 43, 783-791, December 1987, page 784

capture probabilities. This is why this paper, presenting the Chao estimator, is entitled: *Estimating the Population Size for Capture-Recapture Data with Unequal Catchability.*

51. The Chao estimator accounts for this variability that Dr. Sunding recognizes is important. Any further adjustment made by Dr. Sunding is now the same type of adjustment, a second time. By downweighting the frequent anglers while this variability is accounted for in the Chao estimator (the adjustment referred to in Paragraph 45 above), Dr. Sunding is forcing the estimates of the number of anglers to be much lower than they would have been. This is a highly significant error in the use of the Chao estimator as it severely biases any results downward.

52. A simple example follows. Currently all anglers receive a weight of 1.0 – meaning that in counting an individual he represents only himself for that one time he was observed. Now, as an example, suppose I find out that everyone goes fishing twice – everyone, and they are all fishing once in month 1 and once in month 2. Dr. Sunding would make the adjustment to downweight the count of each person. In the formula displayed in Table 1 above, I would get severely limited estimator (N_S)

$$N_S = \frac{\frac{1}{2}F * \frac{1}{2}S}{\frac{1}{2}B} = \frac{1}{2}\frac{F*S}{B}$$

compared to

$$N = \frac{F*S}{B}$$

53. It is clear that the new estimator is only half as much as the old estimator. Dr. Sunding by downweighting with numbers that are fractions less than one guarantees that he severely underestimates the population size. I repeat this demonstration with the Chao estimator used by Dr. Sunding, Again, as an example, everyone fishes twice. Then

Chao's estimator is: $$N_C = f_1 + f_2 + \frac{f_1 f_1}{2 * f_2}$$

but Sunding's Chao estimator is: $$N_D = \frac{1}{2} f_1 + \frac{1}{2} f_2 + \frac{\frac{1}{2} f_1 * \frac{1}{2} f_1}{2 * \frac{1}{2} f_2} = \frac{1}{2}\ N_C$$

54. This error by Dr. Sunding inappropriately and incorrectly forces his result dramatically downward. In my simple example, Dr. Sunding has forced the Chao estimator to be half of what it should be. However, Table 4 of Dr. Sunding's report provides the real adjustment that Dr. Sunding has forced on the Chao estimator.

Dr. Sunding's Table 4: Fishing Frequency of Respondents in the LDW Waterway[14]

Fishing Frequency (times/year)	N
1 - 2	43
3 - 5	28
6 - 10	16
11 - 20	25
21 - 30	7
31 - 50	7
> 50	14
Total (# of anglers)	140
Average (times/year)	**17.7**

[14] Sunding report, paragraph 32

The distribution in Table 4 is obtained from the Mayfield survey, one of the sources on which Dr. Sunding relies. He applies this result to outcomes from the 2016 Windward data collection to obtain a number that is 17.7 times lower than would be obtained through correct use of the Chao estimator. Put another way, Dr. Sunding's estimate is 5.65% of the result of the proper calculation of the Chao estimator.

D.4.3 The Observations Are Taken At Nonrandom Times in Nonrandom Places

55. There are three probability mechanisms at work in the data from the 2016 Windward study on which Dr. Sunding is relying:

a. probability that one observes a member of the population when making a capture of the population (like fish in a lake)
b. probability that a section of the population falls into a sample of the full population (like sampled blocks in a city),
c. probability that a member of the population is available to be counted and is actually a part of the population at the time the capture is made (like homeless people moving in and out of a city where the count is being conducted)

56. Dr. Sunding only accounts for the first of these three. First in this list is the one probability that Dr. Sunding relies on in the traditional capture-recapture study, there is the probability that a member of the population will be observed or not observed. Dr. Chao allows these probabilities to differ from person to person, but everyone has some probability of being caught.

57. Second, in the 2016 Windward study, there is also sampling of times of day and locations. Sampling of times and places can add an unacknowledged (by Dr. Sunding) level of complexity to the data being analyzed. An example is given below. Third, the people being counted are moving at random in and out of the study area, and as noted in the previous section, the method that Dr. Sunding chooses to adjust the counts leads to a severe undercount. A probability mechanism is needed to make such an adjustment.

58. Returning to the second mechanism, there are two forms of sampling being employed by the authors of the studies on which Dr. Sunding relies, and the fishers being observed come and go from the area being studied. One type of sampling is place; another type of sampling is times to observe the fishers.

59. Place coverage is a problem – if you exclude certain places from your sample, you may be excluding some of your population. At the same time the U.S. Decennial Census is conducted, a large operation is launched by the Census Bureau to estimate the number of persons missed by the Decennial Census. This operation is known as the Post-Enumeration Program (PEP). PEP uses Capture-Tag-Recapture ("CTR") estimation methods to estimate the number of people missed in each state by the Decennial Census.

60. There are about 11 million blocks in the United States[15] – all covered by the Decennial Census. To launch the PEP, a sample of blocks, say 11,000, is selected and re-enumerated by an independent group of interviewers using the Census questionnaire, supplemented by a few questions specific to where a person lived on April 1 in the year the Census is taken. The new interviews in the PEP are matched to the Census to determine who was missed in the Decennial Census or in both the PEP and the Census.

61. When the number of people missed by the Census is computed using CTR methods, this number is computed per block (e.g., half a person missed on average) for each of the sampled blocks. With 11,000 blocks, this results in an estimate of 5,500 persons missed in the sampled blocks (11,000 x 0.5).

62. But there are approximately 11,000,000 blocks in the United States. If the blocks in the PEP were sampled randomly in each state, this would mean that the estimate for the United States is 1,000 times larger. In this example, the estimate for the U.S. of persons missed by the Census would be 1,000 x 5,500 = 5.5 million.

63. Dr. Sunding performs his calculation ignoring any type of sampling of place conducted by the authors of the study on which he relies. Just for this reason, his exercise using the Chao estimator is impossible to credit, as Dr. Sunding does not factor in the incomplete coverage of places described in the 2016 Windward study regarding the

[15] In the 2010 Census, this number was 11,078,297.
see https://www.census.gov/geographies/reference-files/time-series/geo/tallies.html

Lower Duwamish.[16] The 2016 Windward study was not intended to be representative of all of the Lower Duwamish, thus no random sampling was done. The 2016 Windward study used adequate methodology for its limited purpose, yet Dr. Sunding's attempt to try to use that study for something more complex fails, as the 2016 Windward study simply does not have coverage of the area to meet this goal.

64. I note, for the purpose of making a comment later, that the PEP interviews people about where they were on Census Day – April 1. If a household has moved and a new household is living at a property on a later date, the new household is asked about who used to live at a location on April 1. Other techniques are also used to ascertain who lived at an address on April 1 – this stabilizes the population so that it is not moving. With the exception of the homeless, everyone has an official address as of April 1. No one is considered to be moving as of April 1, unlike the fishers in the Lower Duwamish who may or may not be fishing on a day when research was done to observe fishers in the area.

65. In the same way that the sample is of locations in the 2016 Windward study on which Dr. Sunding relies, there is a sample of times used in the study. Some days, some locations are visited at certain times. Other days, other locations are visited at other times. Again, for the purpose of observing fishers, this is a reasonable design. But for the purpose of estimating the number of fishers, this undercuts any use of a CTR method.

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[16] Windward Environmental LLC, Lower Duwamish Waterway Fishers Study Data Report, December 23, 2016. PCB-SEATTLE-4482359 to PCB-SEATTLE-4482539

66. This problem is also addressed in other types of CTR studies and estimators. For example, to observe nomadic tribes and count a nomadic population living in a desert, one establishes a sample of watering points. The nomads must come to the watering points to water their herds – they live by herding. To count the nomads coming to a set of watering points, observers are placed at each watering point for a period, say two weeks. The observers count everyone coming to a watering point during the two weeks, and then deduplicate the counts so that full families are enumerated, but only once.

67. The observer must be at the watering point for a full two weeks to capture all herds and herders coming to the watering point. The observation period cannot be intermittent or a sampling of time periods. The length of time is dictated by the lifestyle of the herdsmen, who operate as family units with multiple generations. Children herd sheep and goats, which have to be watered every three to five days. Women are responsible for herding cattle, which have to be watered every five to seven days. Men are the only ones who herd camels, which have to be watered every ten to fourteen days. Thus, the researcher is guaranteed of seeing every family by staying at a watering point for a minimum of fourteen days – two weeks.

68. The 2016 Windward study did not use this approach, or anything like it. Observers only went to specified locations on predesignated days and times. Thus, if a fisher comes to an alternative fishing point, even one in the sample, when no observer is present, they are not captured.

69. Worse still for Sunding's analysis, there aren't even consistent lengths of times of observations at the locations sampled. The 2016 Windward report states that, if no one was fishing when the observer arrived, the observer left and moved on to another site or back to the office. There's no consistency of times and places sampled in the 2016 Windward study, because it was not designed to be used for counting fishers.

70. My conclusion is that Dr. Sunding chose a method that was completely inappropriate for use in counting people who might be fishing in the Lower Duwamish. His use of the method ignores the sampling conducted in the study and grossly underestimates the number of fishers by simply ignoring any fisher who might have come to a location not sampled or arrived at a time not sampled.

71. Furthermore, Dr. Chao's derivation assumes that the population being counted is stationary, not moving in and out of the area being counted. From the examples given earlier regarding the Decennial Census, counting fish in a lake, or jellybeans in a jar, Dr. Chao's estimator only accounts for a likelihood of capture if one returns repeatedly to a stable population.

D.5 Other Problems with Dr. Sunding's Use of The Chao Estimator

72. Dr. Sunding states "I estimate the size of the total LDW angling population using Chao's estimator, a method that is commonly used to estimate population sizes in

the ecology literature"[17] and this sentence concludes with a footnote, number 27, which is a reference to the aforementioned 1984 Chao paper. The derivation in this paper is for the number of classes in a population, not the population size (e.g., the number of types of birds in an area, rather than the number of birds). Dr. Chao notes in her 1984 paper that her method also can be used to estimate the size of a population, but this led Dr. Chao to publish a subsequent paper regarding estimation of population size.

73. Dr. Chao's subsequent paper dealing with estimating population size (not the number of classes) was published in Biometrics[18]. This paper allows the probabilities of capture to vary from person to person (or item to item) in the population, although in both of Dr. Chao's papers the probabilities must be the same from capture to capture. In the model described above in Table 1, the probabilities could vary from capture to capture but were the same from person to person.

74. In her 1987 Biometrics paper, Dr. Chao presents the same derivation of her estimator that she gave in her 1984 paper that Dr. Sunding references. However, she changes the notation she uses. The way the final estimator is presented in 1984 is very different from the way the identical final estimator is presented in 1987.

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[17] Sunding report, paragraph 39.

[18] Chao, Anne. "Estimating the Population Size for Capture-Recapture Data with Unequal Catchability", Biometrics 43, 783-791, December 1987.

$$\theta = d + \frac{n_1^2}{2*n_2} \qquad \text{(1984 Chao paper, equation 6)}$$

$$\hat{N} = S + \frac{f_1^2}{2*f_2} \qquad \text{(1987 Chao paper, equation 8)}$$

$$\hat{N} = f_1 + f_2 + \frac{f_1^2}{2*f_2} \qquad \text{(Sunding, paragraph 40)}$$

75. In these equations, $d = n_1 + n_2$ and $S = f_1 + f_2$, with f_1 (= n_1) the number of individuals observed exactly once, and f_2 (= n_2) the number of individuals observed exactly twice. In Table 2 above in this report, I use the same notation that Dr. Sunding uses, which is the notation found in Dr. Chao's 1987 paper.

76. Dr. Sunding states he relies on the 1984 paper and doesn't mention the more apt 1987 paper, but his notation is exactly that used in the 1987 paper. Dr. Sunding does not mention the 1987 paper in his report or in his list of materials on which he relied.

77. The Chao 1987 paper is broader than the 1984 paper and includes a variance estimator (a means of measuring the reliability of the estimate). Dr. Sunding does not use this variance estimator but relies on an alternative approximation.

78. Dr. Chao also describes an adjustment of the confidence interval on her estimator which results in a much broader margin of error than other methods that she applies to the estimates in the 1987 paper. Dr. Sunding does not use this adjustment.

79. In the 1987 paper, there are multiple admonitions about the inadequacy of the Chao estimator when the number of captures is low, when the probabilities of capture are low, or both. Dr. Sunding ignores these admonitions.

80. As Dr. Chao notes, "our estimates appear to have some negative bias" (Chao, 1987, page 79). From Tables 1 and 2 above in this report, it is clear that there are two types of CTR estimators that could be chosen. One method, described in Table 1, is unbiased. The second method, Dr. Chao's method described in Table 2, is biased and can underestimate the size of the population being studied. Dr. Chao's 1987 paper includes an adjustment to make her method unbiased, but Dr. Sunding ignores this or is unaware of the bias and makes no such adjustment.

81. Finally, Dr. Sunding introduces a modification to the Chao estimator. Recall that the formula for the Chao estimator is

$$\widehat{N} = f_1 + f_2 + \frac{f_1^2}{2*f_2} \qquad \text{(Sunding, paragraph 40)}$$

82. The value, f_2, is the count of persons (or items) observed exactly twice, where f1 is the count of persons observed exactly once. Dr. Sunding adds people he claims are observed three, four, or more times in the count represented by f_2. If this is done in both the linear term of his equation (the second term on the right) and the denominator of the ratio estimate of f_0, this introduces a bias to the estimation process. Dr. Sunding could have used a correct estimator that allows for multiple captures. A three capture Chao

estimator is found in Computational Statistics and Data Analysis[19] and a general model for multiple captures is presented in Seber's book, The Estimation of Animal Abundance.[20]

E. A Summary of the Methodology Employed by Dr. Sunding

83. As noted earlier in this report, Dr. Sunding obtains data from studies conducted by others along the LDW for different purposes. He uses this data in his version of the Chao estimator to extrapolate the number of persons who fish on the LDW.

84. The Lower Duwamish Waterway Fishers Study Data Report (the 2016 Windward report) was conducted as a "first step toward developing effective and appropriate LDW fish consumption ICs.[21]" ICs (Institutional Controls) are warnings specific to resident fish and shellfish consumption. Dr. Sunding relies on this report to estimate the number of fishers in the LDW, despite statements by the authors that the study was not designed for this purpose.

85. The published study clearly says,

The fisher study was not designed to quantify the overall number of fishers using the LDW nor the number of fishers targeting resident versus non-resident fish.[22]

[19] K. Lanumteang, D. Bohning, "An extension of Chao's estimator of population size based on the first three capture frequency counts", in Computational Statistics and Data Analysis, 55 (2011) 2302 – 2311.
[20] George A. F. Seber, The Estimation of Animal Abundance, Macmillan Publishing, New York, 1982.
[21] 2016 Windward report, page ES-1
[22] 2016 Windward report, page ES-2, footnote 1

86. Despite this warning, Dr. Sunding uses the data from the 2016 Windward study to do exactly this. His reliance on this data is not appropriate for a variety of reasons, enumerated by the authors of the study on which Dr. Sunding relies.

87. The study did not collect information that would allow subjects to be personally identified.[23] This made it impossible for the 2016 Windward authors to determine if a person who was interviewed was found again in a second or later effort to collect information.

88. The number of persons who were interviewed more than once, and the frequency of interviews conducted with these individuals, was said to be impossible to determine. The authors note[24] that

an effort was made to use the information gathered as part of the survey to link repeat survey takers (i.e., the fisher's first initial and last four digits of their telephone number were collected). This effort was largely unsuccessful; it was generally not possible to match up survey participants.

89. The authors reiterate a point[25] made at the beginning of their report:

This study was not designed to estimate the total number of fishers on the Duwamish; it is not possible to know how accurately the sample of the population that was surveyed represents the whole Duwamish fisher population. The on-river survey portion of the fishers

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[23] Windward report, page 10
[24] Windward report, page 77
[25] Windward report, page 78

study was not intended to be a truly quantitative survey, but rather a semi-quantitative study.

90. The study also made no effort to survey people who were fishing in boats instead of on the riverbanks, meaning that anyone who would have been included in the count had no chance to be included if their sole efforts at fishing were from boats.[26] This would mean that use of this survey to estimate population sizes would be severely biased downwards since there was also no attempt to count boats, count the number of people fishing in boats, or any other information that would have provided the basis of an enumeration of people fishing but not from the riverbank.

91. The study was modified in the middle of the data collection period because the premier location for sampling, the T-105 fishing pier, was closed due to safety concerns.[27] As a result, from October 2014 through February 2015, sampling of individuals was conducted at the T-105 fishing pier. From March 2015 through May 2015, sampling of individuals was conducted at the Spokane Street Bridge, and from June 2015 through September 2015, sampling was conducted at the T-105 public access area, described as being along the shoreline.

92. This changes the coverage area for individuals who might be sampled in the early part of the year since the places and frequency of contact changed. This will have

[26] Windward report, page 11
[27] Windward report, page 14

an impact on any extrapolation from a sample to a population size. It adds a new level of variability in the probabilities of observing an individual, both with respect to the validity of the extrapolation as well as the reliability of the extrapolation. Recall from an earlier part of this report that the derivation of the Chao estimator allows the probabilities of capture to vary from individual to individual, but that these probabilities for each individual had to be the same for each attempt at observing members in the population. With this change, those assumptions in the Chao estimator are violated and not accounted for by Dr. Sunding.

93. Different locations were surveyed in different ways.[28] On some days and in some locations, surveyors would go to a location and wait two hours to intercept anyone who came in. In other locations, surveyors would go to a location and if no people were fishing during that arrival period, the surveyors moved on to the next location. On "tent days" free coffee was offered with the hope of inducing people fishing to be more likely to interact with the surveyors, meaning the probability of an observation was increased.

94. After the closure of the T-105 fishing pier, other sites were visited more frequently while some of the sites associated with the Spokane River Bridge were not visited. In a study where the intent was to estimate population size, an effort would have been made to stabilize the probabilities of capture of individuals. Without this

[28] Windward report, page 14

stabilization, the Chao estimator is completely inappropriate. Activities described in this paragraph and the previous paragraphs would have made that process less stable with probabilities of capture changing from day to day and from location to location. None of these deviations in procedures are mentioned or accounted for by Dr. Sunding.

95. Survey timing varied in a similar way, with days of the week and time of the day varying, but not in a random way. The authors of the 2016 Windward study made choices of dates and times that relied on what was known from pre-survey interviews and past studies. This means that the selection of these sites was definitely not random.

96. Again, there is no mention of this variability in Dr. Sunding's report. Further, surveys were scheduled only for daylight hours[29] and no questions were asked about twilight or night fishing, so any fishing outside the narrow window imposed on the study was ignored. Dr. Sunding ignores this when he uses the survey to estimate the number of people fishing in the LDW area; it is safe to conclude from this that Dr. Sunding's estimates, in addition to their numerous other flaws, are underestimates, although his analysis provides no means for quantifying the degree of underestimation.

97. The 2016 Windward report states explicitly that some fishers were not included in the survey even though they were found fishing.[30] Sometimes fishers left the location when surveyors arrived, sometimes fishers indicated they were not willing to

[29] Windward report, page 15
[30] Windward report, page 17

speak to a surveyor, and sometimes there were too many fishers at a location and not all could be approached. There was no recording by 2016 Windward of these instances, so there is no way to account for people who left, who did not want to talk, or were part of a large group that could only be partially covered in the survey. For the first two reasons, the common term for missing individuals who did not want to participate is "trap avoidance." In trap avoidance, now the captures are no longer independent, since a person previously caught is less likely to participate in the second capture relative to a person not previously caught. This violates the assumptions in a capture-recapture model, making the application of the capture-recapture model unreliable.

98. The number of persons that declined to be interviewed is substantial.[31] The number of surveys conducted, including repeats, was 403, but there were an additional 379 persons recorded as being fishers who declined to take the survey. A footnote to this count noted that of the 379, there is no way to know if nonrespondents had taken the survey before or if they had declined to take the survey on one or more attempts.

99. The survey of the LDW treats all people interviewed as part of a stable population. A stable population has a fixed size that does not change during the study period. There are no deaths during the one-year period of fishers, nor are there "births" which would include people who moved into an area where the LDW was considered

[31] Windward report, page 30

accessible and a preferable fishing site to other fishing sites. This is called a closed population; namely a population fixed in size with no births or deaths. It is clear from the tabulations in the report that the authors treated the population as being fixed. For example, Figure 4-6[32] "Percent of fishers who reported fishing in each season" could only be tabulated from the data collected by treating the number of fishers as a fixed number, instead of a number that could also change by season.

100. The models in Tables 1 and 2, described above are for closed populations, "closed" meaning the population size does not change between the first and subsequent attempts at counting the population. There are no births and no deaths – nothing comes into the population, and nothing leaves.

101. Open population models exist where it is possible to estimate the size of the population at the first attempt and the size of the population at the second attempt and the population size can grow or diminish. However, now the number of people overall in the population during the time period of the study is equal to the number of people at the beginning of the study, plus the number of births during the time of the study, which can be a much larger number than simply the average number of people present during the time period between the two captures. In a closed population, the

[32] Windward report, page 51

size never changes. In an open population, the population grows in terms of number of people present at some time.

102. This broader model requires estimation of more parameters, namely an intervening birth rate and death rate. Use of a closed population CTR underestimates the size of the population at the end of the process if births are more frequent than deaths.

103. For the purposes of the 2016 Windward report (which did not include estimating the number of fishers), as stated in the introduction to the 2016 Windward report, the approach of observing fishers and interviewing them is appropriate and helpful. However, Dr. Sunding's tacit assumption of a fixed population size is inconsistent with his attempts to estimate population sizes. The 2016 Windward study took a year to conduct, more than enough time for the population size to change substantially.

F. Dr. Pleus' Reliance on Dr. Sunding and Dr. Pleus' Errors in His Own Calculations

104. As it is not possible to rely on Dr. Sunding's calculations, it follows that one cannot rely on Dr. Pleus' use of Dr. Sunding's results. Dr. Pleus, however, makes his own errors in his calculations, compounding whatever problems result in Dr. Pleus' work.

F.6 Dr. Pleus Relies on Artificially Low Numbers from Dr. Sunding

105. Dr. Pleus relies on Dr. Sunding for estimates of fish consumption by non-tribal populations. However, the opinions proffered by Dr. Pleus are sensitive to Dr. Sunding's estimates. Although Dr. Pleus concludes that there is little exposure to the population of anglers eating fish, this is based on Dr. Sunding's very low numbers. Had

Dr. Sunding accounted for the transitory nature of the population, the nonrandom subsets of time and place by the authors of the 2016 Windward study, the biases of the Chao estimator, or had Dr. Sunding not adjusted twice for differential capture probabilities, driving the estimates to an extreme low, then Dr. Pleus would have relied on a much higher number of anglers and exposures of people catching and eating fish from the Lower Duwamish.

F.7 Dr. Pleus Introduces New Mechanisms to Drive the Estimates of Angler Consumption and Exposure Even Lower

106. Dr. Pleus' opinions rely in part on what he describes as a probabilistic risk assessment (PRA). In his back-up materials, he also computes point estimates relying on Dr. Sunding's materials. Dr. Pleus computes these point estimates for lifetime excess cancer risk (LECR) and the Hazard Indices by relying directly on Dr. Sunding's average fish consumption data and plugging in the average fish consumption to the formula used to estimate his risk metrics[33].

107. Thus, he knows what the averages are for LECR and each of the Hazard Index values, and these are found in his back up materials. He then ignored these results that are directly reliant on Dr. Sunding's averages and chose input values to the Monte Carlo simulations that guarantee a much lower risk profile. The direct results Dr. Pleus obtains

[33] See Appendix B, Table B-1, Parameter Distributions for Fish Ingestion in Dr. Pleus' back up materials, Pleus, Richard, 2021-11-22, Seattle Expert Report Appendix A-F 4877-8137-9589 v.1.pdf

using Dr. Sunding's average values are wildly different from the results he obtains from his fatally flawed and unreliable Monte Carlo simulation.

108. Dr. Pleus' tortured computations for inputs to the Monte Carlo simulation are designed to produce the lowest risk for the anglers who in fact have the greatest risk. He does this by substituting the median value of fish consumption instead of relying either on the mean value found by Dr. Sunding or alternatively relying on the deciles describing the range of fish consumption. Dr. Pleus invokes a probabilistic technique (the lognormal distribution[34]) but falls far short of correctly implementing that technique.

109. Dr. Pleus' method is completely contrary to the EPA recommended method of determining the form of a probability distribution. The EPA recommends that, if an analyst has the raw data or six or more percentiles, that the selection of parameter estimates (or the fitting method to fit the distribution) rely on maximum likelihood, regression methods or matching the moments of the distribution. The EPA further states that, if the analyst has only one or two summary statistics that expert judgment can be used. Dr. Pleus has the data available, both in raw form and also as deciles provided by Dr. Sunding in his report and his back up materials.[35]

[34] For a description of the lognormal distribution, see Johnson, Norman L. and Kotz, Samuel, Continuous Univariate Distributions, Volumes 1 and 2,, John Wiley & Sons, New York, 1970.

[35] "Risk Assessment Guidance for Superfund: Volume III - Part A, Process for Conducting Probabilistic Risk Assessment." EPA (2001). Page B-36.
Available at https://www7.nau.edu/itep/main/iteps/ORCA/6338_ORCA.pdf.

110. To demonstrate how seriously flawed Dr. Pleus' methods are, I present three charts. Chart 1 shows the deciles from Dr. Sunding's data, which Dr. Pleus has available from Dr. Sunding's report. These are the actual values offered by Dr. Sunding. In the same chart, I show the lognormal probability distribution derived by Dr. Pleus using the median and standard error of the data from Dr. Sunding.

111. Dr. Pleus chose to apply a lognormal distribution in his analysis, using the median and standard deviation from the Sunding Report in order to model the "median" angler instead of those who have high ingestion rates and most likely to be at risk. Dr. Pleus attempts to justify this derivation by stating:

> *"[T]he mean ingestion rates for all fish types exceed the 80th percentile ingestion rates, demonstrating the effect of very high ingestion rates by a small number of fish consumers on the average ingestion rate. As such, the use of an average fish ingestion rate in the exposure calculations significantly overestimates the exposure to the "median" (i.e., 50th percentile) angler that consumers their catch. Therefore, the location, median, and SD were used to form PDFs for the adult pelagic and benthic ingestion rates.*[36]

112. This sophistic explanation defies two basic statistical principles. First, Dr. Pleus chooses the lognormal distribution, but he doesn't justify or explain this choice. Chart 1 below shows that the lognormal chosen by Dr. Pleus does not fit the distribution

[36] Appendix D-4 of the Pleus Report.

he has from Dr. Sunding, as found in Dr. Pleus's back up materials. The lognormal always has a mean larger than the median, so centering the lognormal distribution at the median simply creates a new probability distribution with a much smaller mean.

113. The definition of the lognormal derives from a transformation of the normal distribution (the bell curve). If Z is a variable that comes from the normal distribution with mean zero and variance 1.0, then $X = exp(\mu + \sigma Z)$ is distributed as a lognormal variable[37]. The reason for doing this is that the new variable that Dr. Pleus is using always has a positive value (necessary for grams of fish consumed).

114. The mean of the lognormal as defined above is $mean = exp\left(\mu + \frac{\sigma^2}{2}\right)$ and the median for the lognormal as defined above is $median = exp(\mu)$. Because σ^2 is always positive, the mean is always greater than the median – which is what one wants in a distribution that can only take on positive values[38].

115. Dr. Pleus uses Crystal Ball to force the distribution he uses to have the median and standard distribution from Dr. Sunding, which has the effect of underestimating the tail of the distribution (the entire distribution on the right). What Dr. Sunding doesn't show is that the resultant mean of the distribution he fits this way is only .9254, not 2.349 as reported by Dr. Sunding.

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[37] exp is a mathematical function meaning that the number "e" is raised to the power found inside the parentheses, where e= 2.718281828

[38] For Equations for definition, mean, and median, see Johnson and Kotz, op.cit.

116. The second problem with the argument that Dr. Pleus offers is that it violates the most basic principles of distribution theory. Almost every probability distribution is characterized by what are defined as "sufficient" statistics[39]. These are derived and unique to every probability distribution. If one knows the sufficient statistics, then these few parameters and the formula for the probability distribution that relies on the sufficient statistics are all that is needed to compute every possible number in the probability distribution – an infinite number of values.

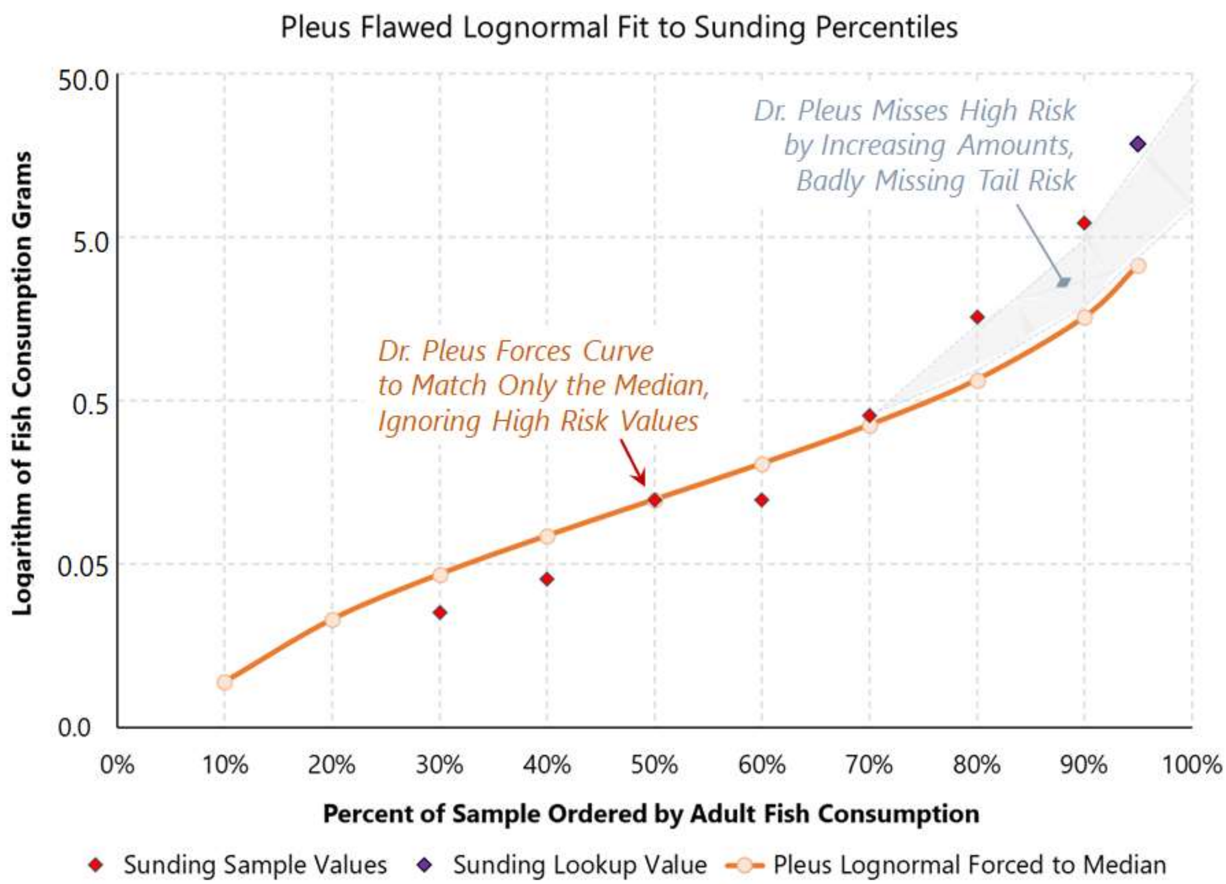
117. The normal distribution is described by its sufficient statistics, the mean and the variance. The same is true for the lognormal – distribution theory tells us the sufficient statistics are the mean and the variance. The median is not a sufficient statistic and cannot be relied on to properly characterize a distribution. For the lognormal distribution, the median is guaranteed to not allow the target distribution to be estimated – the distribution that Dr. Sunding described in his report. Thus, Dr. Pleus completely misses the Sunding distribution because he violates a basic law of distribution theory. Dr. Pleus' methods are inappropriate and unreliable.

118. Chart 1 follows on the next page. On Chart 1, the red diamonds are the actual values found in Dr. Sunding's report and repeated in Dr. Pleus' materials. The goal of Dr. Pleus' analysis using the lognormal distribution is to find a lognormal distribution

[39] Hogg, Allen T. and Craig, Robert V., Introduction to Mathematical Statistics, 3rd Edition, Macmillan Company, New York, 1970

that describes the points that Dr. Sunding described. Dr. Pleus fails completely by implementing a procedure that is simply incorrect. Dr. Pleus' outcomes are described by the orange line that goes through the chart, but only intersects one point – the median.

Chart 1: The Distribution that Dr. Pleus Force Fits to the Median[40]



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[40] Sunding report for actual numbers (red diamonds), percentiles from Sunding report, Table C-1, and reproduced in Pleus report, back up spreadsheets. 95 Percentile computed using Sunding's report tables file, using Sunding's Excel file that computes this value when column header changed.

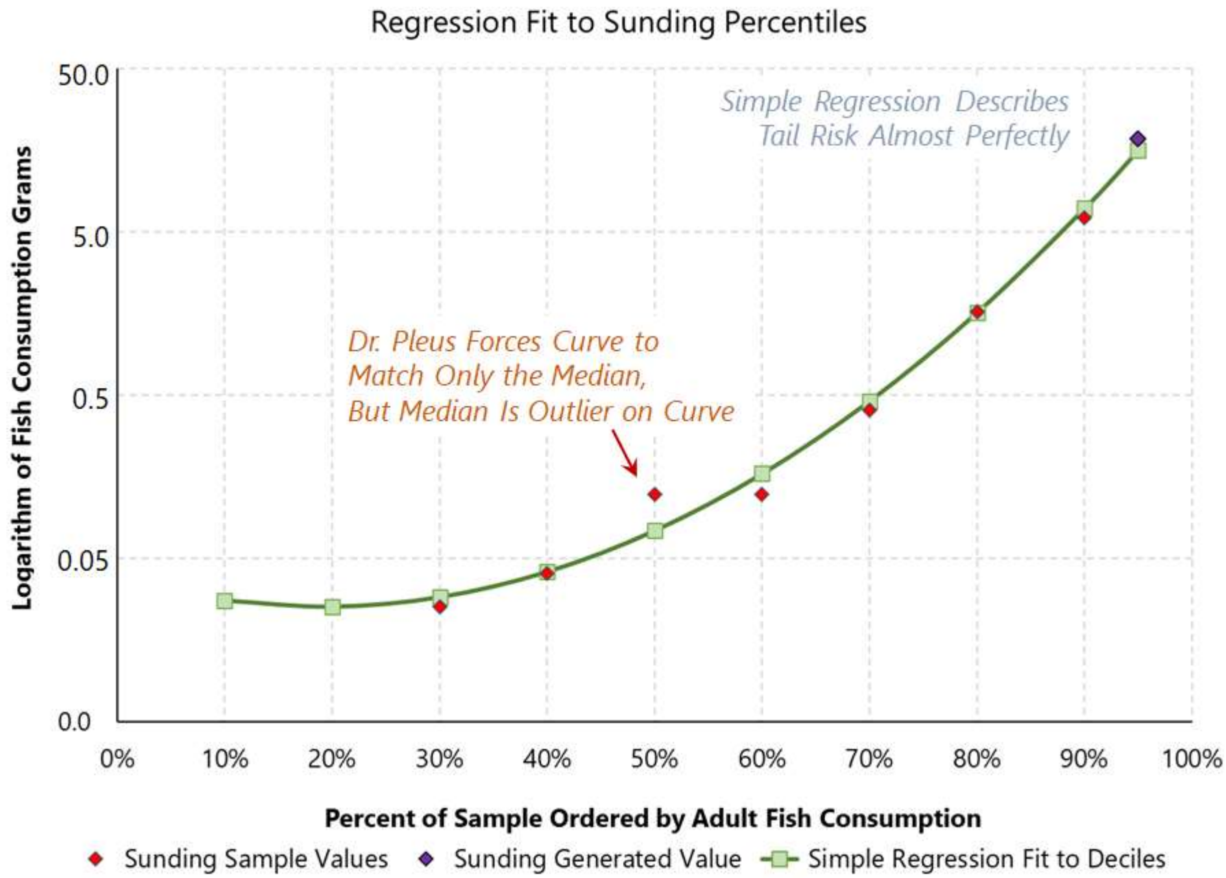
119. In Chart 2, the red diamonds are the same values found in Dr. Sunding's and in Dr. Pleus' reports. However, using a proper distribution, I intersect most of the points from Dr. Sunding's report, with an exception of the median. My function does not intersect with the median because the median is out of line with the remainder of the values.

120. When one considers the entire distribution, or the percentiles summarizing the distribution presented by Dr. Sunding, there is no version of the lognormal distribution that can fit the data shown above in Chart 1. In his choice of the lognormal, and his further choice of choosing to fit the lognormal usingthe median as shown in Chart 1, Dr. Pleus has minimized the true risk for people who are anglers who consume more fish. Chart 1 demonstrates that he completely misses the risk for the upper 30% of those in Dr. Sunding's findings.

121. Dr. Pleus could easily have done this part of the analysis correctly. While he misses the target risk for all percentiles both above and below the median, there was a simpler and more proper solution to the development of the distribution he wanted to characterize. This is shown in Chart 2.

122. I did this with a very simple regression function that describes the relationship for the percentiles with a quadratic equation (meaning it uses a term x and a second term x2, where x is the percent of sample ordered by fish consumption. Dr. Pleus proceeded with an incorrect approach to give his results the patina of scientific validity, but in doing so he abandoned scientific principles that would guide an unbiased review.

Chart 2: A Nearly Exact Fit to Dr. Sunding's Published Data



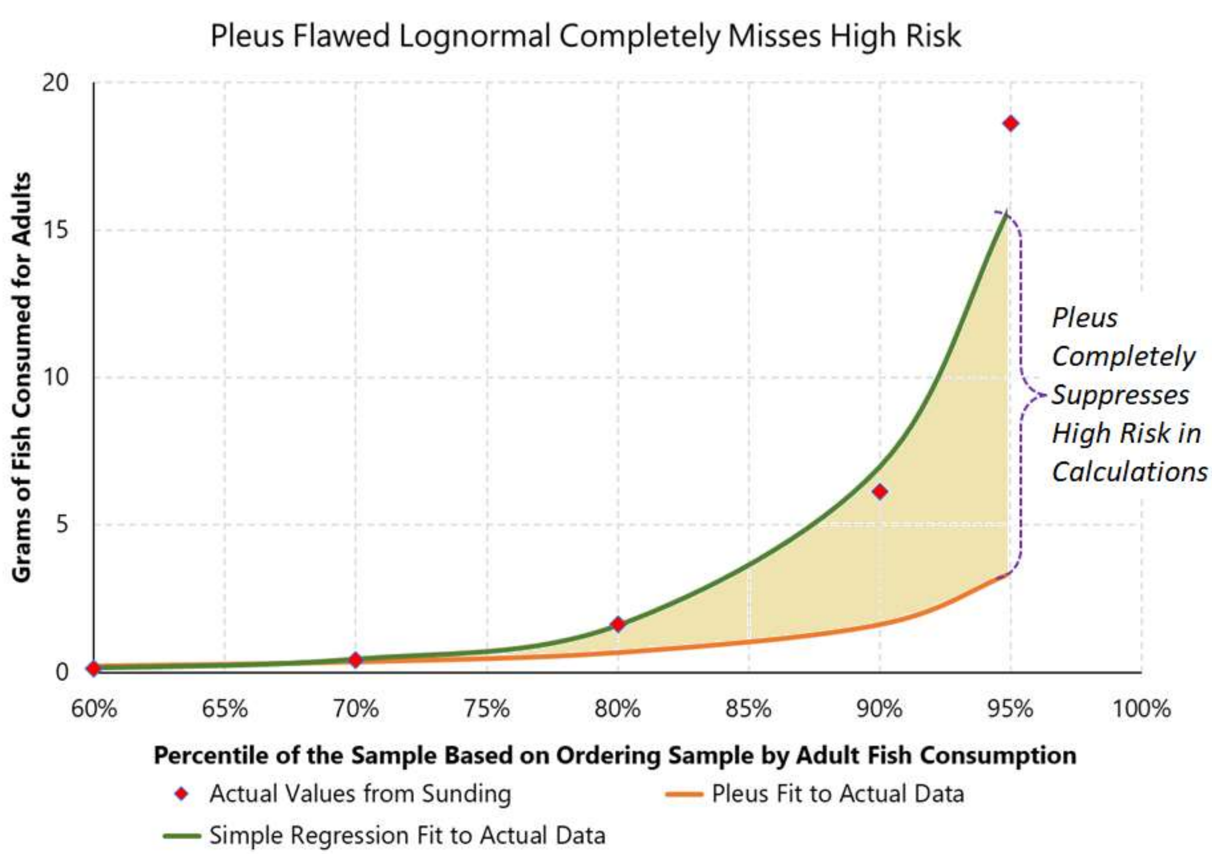
123. Note that the vertical axis in Charts 1 and 2 are on the logarithmic scale. In these charts, the logarithm is a number that is the exponent of ten. Thus, a value of 5 represent the exponent of 10^5 = 10 x 10 x 10 x 10 x 10. A full chart of these values follows:

	Conversion of Logarithmic Values to Actual Numbers				
Logarithm (Base 10)	0	0.05	0.5	5	10
Actual Value	1.00	1.12	3.16	100,000	10,000,000,000

124. To show the effect of Dr. Pleus' analysis, concentrated only on the median value and not with the risk for more frequent fish consumption, I show the difference between the values that Dr. Pleus calculates and the values I calculate, but now presented on the actual scale, not to logarithmic scale. This is shown in Chart 3 on the next page.

125. I note also that Dr. Pleus forced his distribution to the only value that does not fit the much simpler distribution that almost exactly hits the remaining percentile values found in Dr. Sunding's data, which simply exacerbates the bias in Dr. Pleus' analysis. Ultimately there is a severe suppression of risk, as shown in Chart 3.

Chart 3: Description of Bias in Dr. Pleus' Analysis



126. Charts 1 and 2 show the percentiles as a logarithmic function, since that is what Dr. Pleus attempted to do with his lognormal distribution. But visually, this reduces the impact of the bias in Dr. Pleus' methods. Chart 3 presents the same data from Charts 1 and 2, but without a transformation of the number of grams that anglers consumed.

Table 3: Ingestion of Pelagic Fish and Probability Risk Distributions[41]

		Adults		
	pelagic ingestion by adults	Total Lifetime Excess Cancer Risk	Total HI (A1016)	Total HI (A1254)
Percentile		1.58E-05	1.61E-01	5.63E-01
30	0	1.22305E-05	0.124998617	0.437495159
40	0.009	1.22627E-05	0.125326491	0.43864272
50	0.017	1.22912E-05	0.125617935	0.439662773
60	0.043	1.2384E-05	0.126565128	0.442977946
70	0.171	1.2841E-05	0.131228229	0.4592988
80	0.685	1.46761E-05	0.149953494	0.524837229
90	2.57	2.14059E-05	0.218624943	0.765187302
Max	22.336	9.19742E-05	0.938709755	3.285484143
Mean	**0.987**	**1.57543E-05**	**0.160955498**	**0.563344243**

127. Dr. Pleus claims to compute probabilistic risk assessments for the three types of consumption: pelagic , benthic , and shellfish. I recompute these values using Dr. Pleus' formulas and show that there is a proportion of the human population that is at risk from consuming Lower Duwamish fish and shellfish, even accepting Dr. Pleus' metrics for risk tolerance.

[41] 211119 WD Master PRA Dataset.xlsx, Ingestion Rates spreadsheet, Pleus back-up; taken from Table C-1 Consumption Rates by Species for Anglers, in Sunding backup; LECR and HI computed putting these inputs into formulas used by Dr. Pleus

128. By relying only on the mean from Dr. Sunding for this consumption, Dr. Pleus misses finding any risk in the population. Using Dr. Pleus' preferred metric, if the Hazard Index is above 1.0, Dr. Pleus finds that there is a hazard. In this chart, a value of Total HI above 1.0 would be found slightly above the 92nd percentile of the pelagic fish consumption.

129. In the same way, I computed the same indices for ingestion of Benthic fish as shown in Table 4.

Table 4: Ingestion of Benthic Fish and Probability Risk Distributions[42]

		Adults		
	benthic ingestion by adults	Total Lifetime Excess Cancer Risk	Total HI (A1016)	Total HI (A1254)
Percentile		1.58E-05	1.61E-01	5.63E-01
20	0	4.68E-06	0.047972778	0.167904722
30	0.025	4.80E-06	0.049175233	0.172113317
40	0.041	4.88E-06	0.049944805	0.174806817
50	0.124	5.27E-06	0.053936957	0.18877935
60	0.124	5.27E-06	0.053936957	0.18877935
70	0.408	6.61E-06	0.067596852	0.236588981
80	1.632	1.24E-05	0.126469074	0.442641758
90	6.119	3.35E-05	0.34228579	1.198000264
Max	53.178	2.55E-04	2.605739953	9.120089836
Mean	**2.349**	**1.58E-05**	**0.160955498**	**0.563344243**

130. Again, Dr. Pleus chooses to focus only on the mean consumption and ignores the full range of values produced by Dr. Sunding. As can be seen in Table 4, there is a significant lifetime excess cancer risk in the top percentile, there is a total Hazard Index

[42] 211119 WD Master PRA Dataset.xlsx, Ingestion Rates spreadsheet, Pleus back-up; taken from Table C-1 Consumption Rates by Species for Anglers, in Sunding backup; LECR and HI computed putting these inputs into formulas used by Dr. Pleus

value above 1.0 for the HI (A1016) for the top percentile, and there is an exceptionally high Total HI (A1254) for the upper two percentiles (approximately the top 15% of the population eating benthic fish).

131. Finally, Dr. Pleus conducts this analysis for shellfish consumption. Had he done the risk assessment he alleges to have done, he would find the results in Table 5. The results in Table 5 show that there are significant risks as measured by total lifetime Excess Cancer Risk, and the two Hazard Indices. Again, by concentrating only on the mean value produced by Dr. Sunding, Dr. Pleus finds no risk when in fact a properly conducted analysis would have shown unacceptable risk for a portion of the population according to Dr. Pleus' metrics for risk tolerance even relying on Dr. Sunding's artificially low numbers.

Table 5: Ingestion of Shellfish and Probability Risk Distributions[43]

		Adults		
	shellfish ingestion adult	**Total Lifetime Excess Cancer Risk**	**Total HI (A1016)**	**Total HI (A1254)**
Percentile		1.58E-05	1.61E-01	5.63E-01
50	0	1.46633E-05	0.149822343	0.5243782
60	0.023	1.47266E-05	0.150468965	0.526641379
70	0.029	1.47432E-05	0.15063765	0.527231773
80	0.1	1.49388E-05	0.152633746	0.534218109
90	0.932	1.72311E-05	0.176024617	0.61608616
Max	70.874	2.10E-04	2.142375993	7.498315974
Mean	**0.396**	**1.57543E-05**	**0.160955498**	**0.563344243**

[43] 211119 WD Master PRA Dataset.xlsx, Ingestion Rates spreadsheet, Pleus back-up; taken from Table C-1 Consumption Rates by Species for Anglers, in Sunding backup; LECR and HI computed putting these inputs into formulas used by Dr. Pleus

132. To demonstrate how severely Dr. Pleus' results would change if Dr. Sunding's results were more credible, consider multiplying Dr. Sunding's results to increase them, for example by multiplying by 2.0 to counteract the impact of Dr. Sunding's double "correction" for varying probabilities of capture. In each of these tables above, there would be a very substantial portion of the population at risk even according to Dr. Pleus' stated metrics.

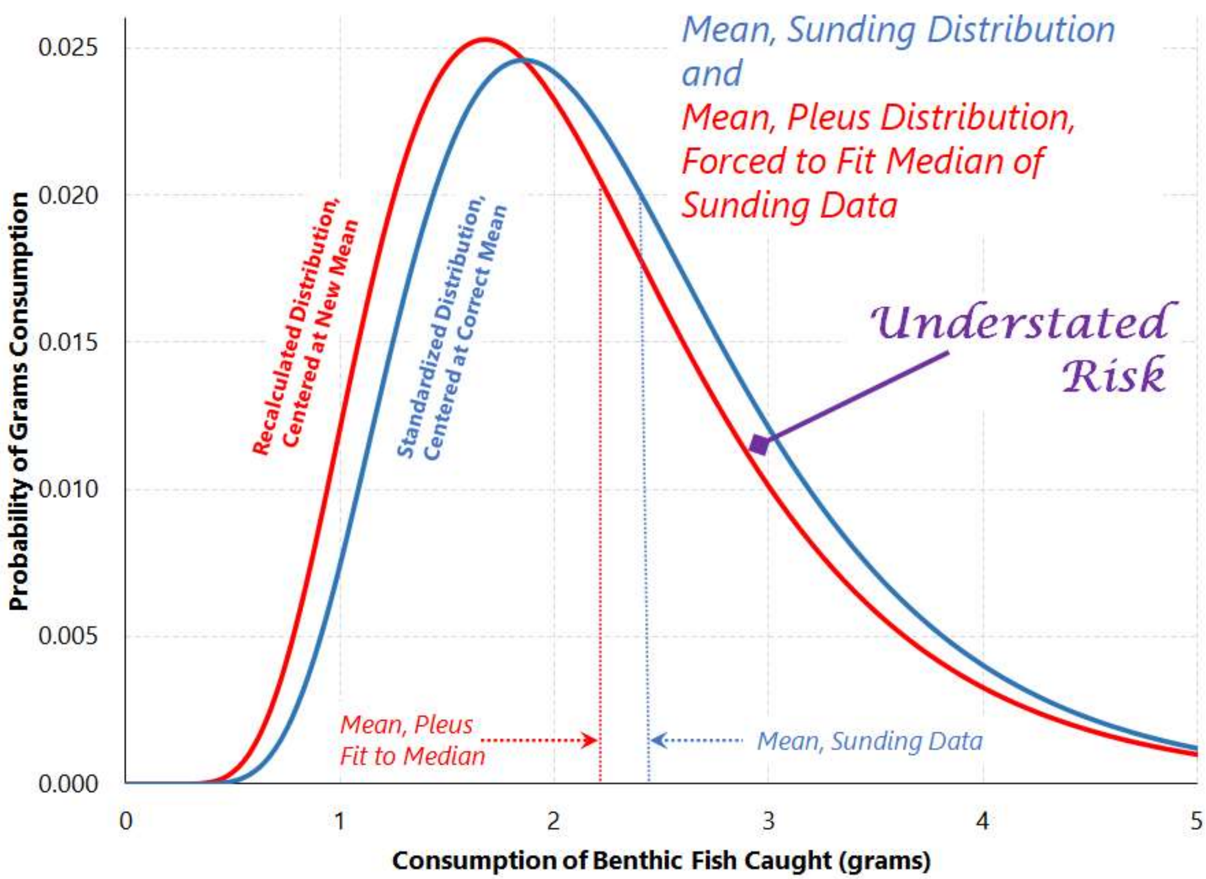
133. However, given the number of errors and misunderstandings found in Dr. Sunding's work, it is impossible to believe that the multiplication should be only by a factor of 2.0. Since Dr. Sunding's work is so extremely flawed, it is impossible to say anything more about what the factor increasing the rate of ingestion should be. But the concept of increasing Dr. Sunding's results by even a small amount demonstrates how dependent Dr. Pleus' results are on proper inputs.

134. My conclusion is that, by focusing only on the median values from Dr. Sunding and ignoring the distribution of outcomes that Dr. Sunding reports, Dr. Pleus hides the risk that should be obvious had he done the probability risk assessment he avers he made. Chart 4 demonstrates this visually.

135. Chart 4 was computed by using the lognormal distribution twice. The blue line is computed so as to reproduce the mean of Dr. Sunding's data. The red line is computed so as to reproduce the mean of the new distribution that comes about because Dr. Pleus solves for a lognormal distribution that fits the median, not the mean. In both

cases, I standardized the data so both analyses have an identical standard error of 1.0. I do this to concentrate the analysis only on the actual mean computed by Dr. Sunding and the newly derived mean that Dr. Pleus obtains by forcing the median of the lognormal distribution to match the median of Dr. Sunding's data.

Chart 4: Description of Bias in Dr. Pleus Use of the Median to Parametrize the Lognormal Distribution Instead of the Mean



136. The reason that the two means are different is because the data is not distributed according to the lognormal distribution. Chart 1 showed that Dr. Pleus' computation of a lognormal distribution badly underestimates the risk in the upper tail

of the distribution he chose. In effect, he shifted the distribution to the left, as shown in Chart 4. The following table reiterates these values.

	Dr. Pleus' Fit to Median	Fit to Dr. Sunding's Mean	Values from Dr. Sunding's Report
Median	**0.124**	0.204	**0.124**
Standard Dev.	**6.843**	**6.843**	**6.843**
Mean	2.192	**2.349**	**2.349**

137. The key component to Chart 4 is the refitting of the distribution so that the median of my example distribution is used instead of the mean, when the lognormal distribution is the wrong choice for a distribution. This demonstrates exactly the outcome when this device is used to force the lognormal distribution to the left, forcing exposures to PCBs from ingestion to be far lower than they actually are, particularly in the right-hand tail of the distribution where the greatest risk is for anglers who consume their catch.

F.8 Dr. Pleus' Disregard for Proper Statistical Method and the EPA Guidelines

138. Dr. Pleus states he applied principles and policies described in:

- U.S. EPA, 1997. Guiding Principles for Monte Carlo Analysis. United States Environmental Protection Agency. Washington, D.C. EPA/630/R-97/001. March.

- U.S. EPA, 2001. Risk Assessment Guidance for Superfund: Volume III - Part A, Process for Conducting Probabilistic Risk Assessment. United States Environmental Protection Agency. Washington, D.C. EPA 540-R-02-002. December.

139. However, a review of his report in light of the above guidance reveals gaps that Dr. Pleus used to both bias his results towards finding no significant cancer or non-cancer risks while simultaneously concealing his assumptions that are responsible for the bias.

140. A guiding principle for Monte Carlo simulations is to provide detailed information on the input distributions selected and to discuss the goodness of fit when choosing a particular probability distribution corresponding to the empiric input distribution.[44] Dr. Pleus uses a Monte Carlo simulation and selects a particular probability distribution, the lognormal. Dr. Pleus did not present any analysis or discussion on the goodness-of-fit for his chosen distributional assumptions for fish ingestion rates.

141. As described above, Dr. Pleus' choices severely bias both the upper tail levels and the mean values of exposure downward relative to the Sunding Report. Further it is not the preferred method as described in EPA guidance on probabilistic risk assessments. Any hope of assessing the proportion of the population that is at risk is wiped out by Dr. Pleus' use of a median and standard deviation to parameterize a distribution when the proper sufficient statistics for that distribution are the mean and standard deviation.

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[44] Provide detailed information on the input distributions selected. This information should identify whether the input represents largely variability, largely uncertainty, or some combination of both. Further, information on goodness-of-fit statistics should be discussed." See page 17 of "Guiding Principles for Monte Carlo Analysis." EPA (1997).
Available at https://www.epa.gov/sites/default/files/2014-11/documents/montecar.pdf.

142. The EPA's preferred method would have been to use the deciles from Dr. Sunding's study to fit a proper distribution. Dr. Pleus cites to Dr. Sunding's table of percentiles and could have fit a regression in the way I did in Chart 2 above. This easy alternative using data already in Dr. Pleus' back up materials (taken from Dr. Sunding) would be the proper way to fit the distribution and is what the EPA recommended. Dr. Pleus chose a method that is not reliable, not accepted in the technical literature, and is therefore inappropriate.

143. Again, Dr. Pleus ignored guidelines to present a recommended analysis that exposed his biased methods. The EPA suggests that the upper tail (e.g., 95th percentile) is of greatest interest when characterizing the variability of exposure in the numerator of the risk equation.[45]

144. Dr. Pleus chose a distribution for adult benthic fish consumption that fits Dr. Sunding's data badly and greatly underestimates the upper tails observed in Dr. Sunding's data. This renders his opinions concerning risks to the highest-end users unreliable and misleading.

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[45] "The tails of a distribution (e.g., < 5th and > 95th percentiles) for an input variable are often of greatest interest when characterizing variability in risk. Distributions fit to data may not characterize the tails of the distribution in a way that represents the target population. In general, the importance of uncertainty in the fit of the tails of particular distributions should be determined on a site-specific basis. For exposure variables in the numerator of the risk equation, the upper tail is of greatest concern. For exposure variables in the denominator of the risk equation, the lower tail is of greatest concern." See Page B-34 of "Risk Assessment Guidance for Superfund: Volume III - Part A, Process for Conducting Probabilistic Risk Assessment." EPA (2001). Available at https://www7.nau.edu/itep/main/iteps/ORCA/6338_ORCA.pdf.

145. Although Dr. Pleus does nothing to examine the tails of the distributions for the various indices he computes, he states:

Using conservative health-protective methods and data I conclude that hypothetical cancer and non-cancer risks for users of the LDW who consume fish and shellfish from the LDW and who use its waters, beaches and sediments for recreational activities – even the highest-end users -- are all within acceptable ranges.[46]

146. From the previous descriptions of the analyses actually performed by Dr. Pleus, it is clear that this statement he makes is simply false. He performs an analysis that is contrary to the EPA guidelines, contrary to sound statistical practice, and is unreliable.

147. Even more astounding is the fact that Dr. Pleus' results now contradict those offered by Dr. Sunding. Dr. Sunding finds that the 95th percentile of Adult Benthic Fish Consumption is at a rate of 18.64 – a number that can readily be found in Dr. Sunding's materials. Dr. Pleus, after his tortured machinations, finds the same rate to be only 3.35, less than 18% of the number found by Dr. Sunding. Dr. Pleus considers the 95th percentile as the "worst case" scenario but drives his numbers down even further from Dr. Sunding's very low fish consumption rates.

148. This means the "worst case" exposure should be approximately 5.56 times greater than Dr. Pleus contends if he relies on Dr. Sunding's data.

149. Another guiding principle espoused by the EPA is that the researcher should

[46] Pleus Report, paragraph 57

Calculate and present point estimates. Indicate where the point estimate falls on the distribution generated by the Monte Carlo analysis. "Usually, when a major difference between point estimates and Monte Carlo results is observed, there has been a fundamental change in data or methods. Comparisons need to call attention to such differences and determine their impact."[47]

150. Dr. Pleus did not present a comparison of point estimates and those same points computed from his Monte Carlo results. By not presenting a comparison, Dr. Pleus avoided explaining the significant differences between the two, likely caused by ill-fitting and biased distributional assumptions described earlier.

151. Two outcomes below compare the absurd results of Dr. Pleus' Monte Carlo Simulation with the point estimates that the Monte Carlo process should have provided.

Table 6: Comparison of Monte Carlo Simulation Means with Corresponding Point Estimates (LECR is Lifetime Excess Cancer Risk)

Source of Estimate	Adult Lifetime Excess Cancer Risk (x10^-6)	Adult Hazard Intensity (A1254) (x10^-2)
Dr. Pleus' Results relying directly on Dr. Sunding[48]	15.8	56.33
Dr. Pleus' Results that are outputs from Dr. Pleus' Simulation[49]	1.2	20.87
Forced Reduction in Average Risk Due to Dr. Pleus' Faulty Simulation Methods	**92%**	**63%**

[47] See page 19 of "Guiding Principles for Monte Carlo Analysis." EPA (1997). Available at https://www.epa.gov/sites/default/files/2014-11/documents/montecar.pdf.
[48] Op Cit., Sunding, Table C-1, repeated in Pleus back up spreadsheets
[49] 220114 PRA Results. xlsx, spreadsheets CR-General and HI-General, in Dr. Pleus' backup,

152. The Monte Carlo simulation average for adult LECR is a reduction of more than 90% of the point estimate that Dr. Pleus derives from Dr. Sunding's materials. The Monte Carlo simulation mean adult HI (A1254) rate is a reduction of almost two-thirds of the hazard that Dr. Pleus computed from Dr. Sunding's materials.

153. The Monte Carlo simulations are supposed to have mean values equal to the means that were being simulated. To have such incredibly low values can only be the result of a significant failure of Dr. Pleus' methodology to faithfully simulate the distributions from Dr. Sunding. Dr. Pleus' methods are flawed, exceptionally biased to produce a rate so low as to be not credible, even compared to Dr. Sunding's own results that are the outcomes being simulated. Dr. Pleus' analysis is unreliable.

G. Conclusions

154. For the reasons set forth above, I conclude that the results from Dr. Sunding are unreliable and inappropriate. His improper reliance on two studies that were not appropriate to the calculations he attempted completely nullify any conclusions he offers.

155. I also conclude that Dr. Sunding's adjustments to the Chao estimator cause him to underestimate the number of anglers by a factor of over 17.

156. I conclude that Dr. Eaton relies heavily on the results from Dr. Sunding's report and so his computations deriving therefrom are invalid and unreliable, since Dr. Sunding's results are unreliable and invalid.

157. I conclude that Dr. Pleus relies heavily on the results from Dr. Sunding's report and so his computations fail entirely since Dr. Sunding's results are unreliable and invalid.

158. Dr. Pleus takes additional steps to understate the amount of risk that anglers face from cancer and other possible diseases as a result of exposure to PCBs. Dr. Pleus' statistical analyses violate basic principles in statistics and increase the unreliability and inappropriateness of his work and his conclusions.

Date: February 14, 2022

Charles D. Cowan

Charles D. Cowan, Ph.D.

Exhibit 1: Dr. Cowan's CV

Charles D. Cowan is Managing Partner of ANALYTIC FOCUS LLC. Dr. Cowan has 40 years of experience in statistical research and design. He consults for numerous public and private sector entities on the design, implementation, and evaluation of research and the synthesis of statistical and sampling techniques for measurement.

Dr. Cowan has designed some of the largest and most complex research programs conducted by the Federal Government, including the Post Enumeration Program conducted by the Bureau of the Census to evaluate the 1980 Decennial Census, the Economic Cash Recovery valuations conducted by the Resolution Trust Corporation in 1990-95, and many evaluation studies conducted for the Justice Department, the Department of Defense, the Department of Housing and Urban Development, and the Treasury Department. He has provided expert advice to corporations and government agencies on the incorporation of complex research designs in demographic and economic measurement problems, including:

- Development of procedures used by the Resolution Trust Corporation and the FDIC for determination of the value of all assets held by the RTC\FDIC taken from failed banks and S&Ls. Results from this research were used in quarterly reports to Congress on the loss to the American taxpayer that resulted from these failures. These estimates of anticipated recoveries on assets were also used by the RTC and FDIC for financial reporting.

- Establishment of audit and sampling methods to determine the completeness and reliability of reporting and record systems. These procedures were used to both expand and streamline bank examinations for safety and soundness and also compliance measurement for the FDIC. These sampling techniques are applied in the audit of Federal agencies concerned with regulatory review of operations and systems, and related systems for banks, regulatory agencies, and law firms;

- Application of econometric and biometric procedures for measurement of credit risk in large portfolios of loans. These models are frequently used for a variety of purposes within financial institutions, such as the pricing of loans, the management of customers long term, decision making on workouts for delinquent loans, and for establishment of economic and regulatory reserves.

- Evaluation of research conducted for the Department of Defense, for the National Institutes of Health, and for the Department of Agriculture, each in response to Congressional inquiries on the validity of published results, and also for defendants in lawsuits involving evidence proffered by plaintiffs in furtherance of their suit.

- Model fitting and development of projection methods to measure the likelihood of loss or errors in recording in loans held by banks or put up for auction; measurement of the

likelihood of fraud and/or noncompliance in systems, including bank holding companies, trading activities for brokers, and systems for compliance with health department and judicial requirements;

- Development of procedures used by the Bureau of the Census for apportionment of population for revenue sharing purposes and the estimation of the undercount in the Decennial Census of Population and Housing. These procedures include application of capture-recapture methods to measure the size of the undercount in the decennial census, use of network sampling as an alternative measure for population size, and measurement of the reliability of data collected in the Census.

- Development of statistical methods to quantify the size of populations, including nomadic populations for the Census of Somalia, the undercount and overcount in the Census of Egypt, the number of missing children in Chicago, IL, and the number of homeless persons and families needing services in several large cities with transient populations.

Dr. Cowan teaches graduate and undergraduate courses in survey methods, statistics, and computer methods for analysis. He is the co-author of two books, one on evaluation of survey and census methods and one on econometric measures related to the welfare of the U.S. economy. He has written numerous articles on statistical methods, sampling, rare and elusive population research, and optimization techniques.

Prior to cofounding ANALYTIC FOCUS LLC, Dr. Cowan was a Director with ARPC and with Price Waterhouse, where he specialized in financial research and audit sampling. From 1991 to 1996, Dr. Cowan was the Chief Statistician for the Resolution Trust Corporation and the Federal Deposit Insurance Corporation, where he designed research necessary to measure the loss from the Savings & Loan Crisis of the late 1980's. Dr. Cowan also served as the Chief Statistician for the U.S. Department of Education, where he designed large-scale surveys of educational institutions to measure resource needs and availability, and for Opinion Research Corporation, where he designed predictive models of demand for automobile manufacturers, banks, and large horizontally diverse firms like GE and AT&T. Dr. Cowan worked for the U.S. Bureau of the Census, where he was the Chief of the Survey Design Branch and developed many of the techniques in use today for the evaluation of coverage in surveys and censuses.

Education

Ph.D., Mathematical Statistics, The George Washington University, 1984
M.A., Economics, The University of Michigan, 1973
B.A., English and B.A., Economics, The University of Michigan, 1972

Professional Experience

Co-Founder, ANALYTIC FOCUS LLC, January, 2002 to present.
Director, ARPC, November, 1999 to December, 2001.
Director, PricewaterhouseCoopers LLP, January 1997 to November, 1999.
Chief Statistician, Federal Deposit Insurance Corporation / RTC, 1991 to 1996.
Chief Statistician, Opinion Research Corporation, 1989 to 1991.
Chief Statistician, National Center for Education Statistics, US Dept. of Education, 1986 to 1989.
Bureau of the Census: Assistant Division Chief, International Statistical Programs Center, 1984 to 1986; Staff Liaison for Statistical Litigation Support, 1983 to 1984; Chief, Survey Design Branch, Statistical Methods Division, 1978 to 1983; Acting Chief, Survey Analysis and Evaluation Branch, Demographic Surveys Division, 1976 to 1978; Office of the Chief, Statistical Research Division, 1975 to 1976
Survey Research Center, Oregon State University: Manager, 1974 to 1975
Institute for Social Research, U. of Michigan: Assistant Study Director, 1972 to 1974.

Professional Associations

Professor, Statistics, University of Alabama – Birmingham
Associate Professor, Statistics, George Washington University
Visiting Research Professor, Survey Research Laboratory, U. of Illinois

Professional Societies – Memberships

American Statistical Association (ASA)

Professional Societies - Positions

President, Research Industry Coalition, 1999-2000
Council Member, Research Industry Coalition, Representative from ASA, 1995-2000
President, Washington/Baltimore Chapter of AAPOR, 1998
Program Chair, American Association for Public Opinion Research, 1991-1992
Program Chair, Section on Survey Research Methods, ASA, 1989-90
Secretary-Treasurer, AAPOR, 1985-1986
Associate Secretary-Treasurer, AAPOR, 1984-1985
Editorial Board, Public Opinion Quarterly, 1980-1984
Editorial Board, Marketing Research, 1989-2000
Chair, Conference Committee, AAPOR, 1982-1989
Chair, Committee on Privacy and Confidentiality, ASA, 1980-1981

Publications

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Exhibit 2: Testimony in Past Four Years

Financial:
MBIA v Credit Suisse. Worked for plaintiff. Deposed in January 2016. Trial in July 2019.

Christopher S. Porrino, Attorney General of New Jersey on behalf of Amy G. Kopleton, Deputy Chief of the New Jersey Bureau of Securities, v. Credit Suisse Securities (USA) LLC, Credit Suisse First Boston Mortgage Securities Corp., and DLJ Mortgage Capital, Inc., Worked for plaintiff. Deposed in November 2018.

Federal Home Loan Bank of Boston v. Nomura; Federal Home Loan Bank of Boston v. Credit Suisse Securities (USA) LLC, Credit Suisse First Boston Mortgage Securities Corp., Worked for plaintiff. Deposed in January 2019, day 1, February 2019, day 2.

Financial Guaranty Insurance Company v. Morgan Stanley ABS Capital I Inc. and Morgan Stanley Mortgage Capital Holdings LLC, as successor to Morgan Stanley Mortgage Capital Inc., Worked for plaintiff. Deposed in May 2019.

AMBAC Assurance Corporation et al v. First Franklin et al. Worked for plaintiff. Deposed in December 2019.

FDIC v. First Horizon Asset Securities Et al. Worked for plaintiff. Deposed in April 2021.

AMBAC Assurance Corporation et al v. Nomura et al. Worked for plaintiff. Deposed in May 2021.

Financial - non RMBS
Charles Baird and Lauren Slayton, as individuals, and on behalf of all others similarly situated, and on behalf of the BlackRock Retirement Savings Plan v. BlackRock Institutional Trust Company, N.A.; BlackRock, Inc.; The BlackRock, Inc. Retirement Committee; The Investment Committee of the Retirement Committee; The Administrative Committee of the Retirement Committee; The Management Development & Compensation Committee, Catherine Bolz, Chip Castille, Paige Dickow, Daniel A. Dunay, Jeffrey A. Smith; Anne Ackerley, Amy Engel, Nancy Everett, Joseph Feliciani Jr., Ann Marie Petach, Michael Fredericks, Corin Frost, Daniel Gamba, Kevin Holt, Chris Jones, Philippe Matsumoto, John Perlowski, Andy Phillips, Kurt Schansinger, Tom Skrobe; Kathleen Nedl, Marc Comerchero, Joel Davies, John Davis, Milan Lint, Laraine McKinnon, and Mercer Investment Consulting. Worked for plaintiffs. Deposed in May 2019.

Disparate Impact \ Discrimination:
River Cross Land Company, LLC v. Seminole County, FL. Worked for plaintiff. Deposition, Oct. 2019.

County of Cook v. Bank Of America Corporation. Worked for plaintiff. Deposition, February 2021.

County of Cook v. Wells Fargo Corporation. Worked for plaintiff. Deposition, November 2021.

Construction Defects:
Donald Melosh, et al. v. Western Pacific Housing, Inc., JAMS Case No.: 1100091610, Construction Defects. Worked for defense. Deposition, March 2020.

Other Cases:
Pudlowski v. St. Louis Rams. Worked for plaintiff. Deposed in September 2017. Deposed again in October 2018.

Elena Tyurina v. Urbana Tahoe TC LLC, Urbana Tahoe Beverage Company, LLC dba Beach Retreat and Lodge Tahoe, and Action Motorsports of Tahoe, Inc. Worked for Defendant. Deposition, April 2018.

In Re: Dicamba Herbicides Litigation. Worked for plaintiffs. Deposition, March 2019.

Otter Products et al, v. Phone Rehab et al. Worked for plaintiff. Deposed in November 2019.

Thomas Allegra et al v. Luxottica Retail North America. Worked for plaintiff. Deposed in December 2019.

Westgate Resorts v. Reid Hein & Associates, dba Timeshare Exit Team. Tortious Interference case. Worked for plaintiffs. Deposition, March 2020.

Charles Copley et al Bactolac Pharmaceutical, Inc. et al. Worked for Plaintiffs, Deposed August 2020.

Mildred Clemmons et al v. Samsung Electronics of America, Inc. Worked for plaintiffs. Deposed in October 2020.

Epic Tech, LLC v. Fusion Skill, Inc. et al. Worked for defendant. Deposition in January 2021.

Jason R. Sheldon, Steven Hunsberger, et al. v. State Farm Mutual Automobile Insurance Company et al. Worked for plaintiffs. Deposition in March 2021.

Office of the Attorney General, District of Columbia v. SCF Management, LLC and Jefferson 11th Street, LLC. Worked for Plaintiff. Deposition, April 2021.

Monster Energy Company v. Vital Pharmaceuticals, Inc. and John H. Owoc. Worked for Plaintiff. Deposition, June 2021.

In re: Purdue Pharma et al, debtors. Worked for West Virginia. Deposition, July 2021. Hearing, August 2021.

Exhibit 3: Materials Relied On

Plaintiff's First Amended Complaint, File 05/04/16

Windward 2016 Report: Lower Duwamish Waterway Fishers Study Data Report, Dec. 23, 2016, Bates 4482359

Guiding Principles for Monte Carlo Analysis, EPA/630/R-97/001, March 1997

Fish Consumption Survey of the Suguamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region, August 2000 and Appendices

Expert Report of David L. Sunding, Ph.D., submitted November 22, 2021 plus backup materials

Expert Report of Dr. Richard C. Pleus: Human Health Risk Assessment for PCB Contamination in the Lower Duwamish Waterway, submitted November 22, 2021 plus backup materials

Expert Report of David L. Eaton, Ph.D., DABT, FATS, submitted November 22, 2021 plus backup materials

Plus materials referenced in footnotes throughout report